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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an ophthalmologic apparatus and, more particularly, to an ophthalmologic apparatus for picking up an image of an eye to be examined, obtaining the position of a bright point formed by a light beam radiated onto the eye to be examined by image processing, and measuring the curvature of a cornea or the eye refracting power.

Related Background Art

[0002] When the curvature of a cornea or the eye refracting power is measured in an ophthalmologic apparatus, a light beam is radiated onto an eye to be examined, and the position of a bright point (a point illuminated with reflected light) formed by light reflected by the cornea or the fundus of the eye of the radiated light beam must be obtained.
[0003] In order to obtain this position, a method of picking up an image of the eye to be examined, and executing image processing is known. At this time, one bright point normally extends over a plurality of pixels.
[0004] For this reason, the apparatus comprises a program and an MPU (microprocessor) for obtaining the position of the bright point with high precision, and the program is executed by the MPU. Alternatively, the apparatus may comprise a special-purpose hardware arrangement for realizing this processing.
[0005] Fig. 12 is a flow chart showing an example of the program. The operation of this flow chart will be described below.
[0006] Pixels for one frame of the eye to be examined are stored in a memory. The memory memorizes luminance data in units of pixels (step S1).
[0007] Then, the image of the eye to be examined is divided into a plurality of regions, each of which is expected to include one bright point. The luminance data of all pixels in each region are scanned in units of regions, and are compared with a predetermined threshold to detect pixels exceeding (or equal to or larger than) the threshold. The positions of the detected pixels are memorized (steps S2 to S5).
[0008] The centroid of the pixels exceeding (or equal to or larger than) the threshold is calculated for each region, and is determined as the position of the bright point (step S6).
[0009] As an example of the special-purpose hardware arrangement, a technique disclosed in Japanese Laid-Open Patent Application No. 63-49131 is known. This special-purpose hardware arrangement stores pixels in an image memory, and supplies luminance data and position information of pixels exceeding the threshold to the MPU. The MPU calculates the centroid of pixels exceeding (or equal to or higher than) the threshold for each region, and determines it to be the position of the bright point.
[0010] However, in the technique for causing the MPU to execute the program, the luminance data of all pixels must be scanned, and must be compared with a predetermined threshold to detect pixels exceeding (or equal to or higher than) the threshold. For example, in an image defined by 512 x 512 pixels, the total number of pixels is 262,414, and even if a high-speed MPU is used, too much time is required for processing.
[0011] In the example comprising the special-purpose hardware arrangement, the arrangement of the apparatus is complicated, resulting in an expensive apparatus.
[0012] US-A-4859051 describes an eye testing apparatus having a cornea measuring system for projecting an annular pattern for measuring the radius of curvature of the cornea. The eye testing apparatus has electric circuitry which includes a control unit which performs calculations with regard to image data received from a charge coupled device (CCD). A frame memory is connected to the control circuit for memorising data for one image screen. Other memories are provided for storing measured characteristics of the eye being tested calculated from the data stored in the frame memory.
[0013] US-A-4678297 describes an ophthalmic instrument for effecting eye measurement with a target mark projected onto the eye being examined, and a control circuit for determining the accuracy of alignment of the eye to be examined. When the amount of deviation of alignment of the eye exceeds an allowable value, the apparatus outputs a warning to that effect.

SUMMARY OF THE INVENTION

[0014] It would be beneficial to provide an ophthalmologic apparatus, which can execute processing for detecting the position of a bright point at high speed, and has a simple, inexpensive arrangement of the apparatus.
[0015] In accordance with the present invention there is provided an ophthalmologic apparatus comprising:

radiation means for radiating light onto an eye to be examined;

image pickup means having a number of pixels for producing image data of the eye to be examined, which is irradiated with light emitted from said radiation means;

comparison means for comparing the image data produced by pixels of said image pickup means with a threshold determined in advance for the image data;

memory means for storing information indicating the position of a pixel producing image data which is determined to be larger than said threshold by said comparison means; and

calculation means for calculating a value corresponding to a characteristic of the eye to be examined on the basis of said position information stored in said memory means,

characterised in that said comparison means is arranged to perform said comparison of said image data in real time as the image data is outputted from the image pickup means.

[0016] The apparatus may further comprise:

first memory means in which the threshold is stored,

said comparison means comparing the image information values when directly input from the image pickup means with the threshold memorized in the first memory means.

[0017] The image pickup means may comprise a plurality of pixels, and

the memory means may memorize information associated with at least one pixel from which an image information value larger than the threshold is obtained.

[0018] Furthermore, the calculation means may calculate the curvature of the cornea of the eye to be examined or the eye refracting power of the eye to be examined.

[0019] In the ophthalmologic apparatus of the present invention, required measured values of an eye to be examined, whose image is picked up by the image pickup means, can be calculated at high speed, and the apparatus has a simple, inexpensive arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a diagram showing an optical system of an ophthalmologic apparatus for measuring the curvature of a cornea according to an embodiment of the present invention;

Fig. 2 is a view showing an image picked up by an image pickup unit shown in Fig. 1;

Fig. 3 is an explanatory view of regions and bright points according to the first embodiment of the present invention;

Fig. 4 is a block diagram of a bright point position detection unit according to the first embodiment of the present invention;

Fig. 5 is a circuit diagram of a memory controller according to the first embodiment of the present invention;

Fig. 6 is a view for explaining an example of the intensity distribution of luminance;

Fig. 7 is a view showing an example for calculating the area of a bright point from one pixel;

Fig. 8 is a view showing an example for calculating the centroid;

Fig. 9 is a block diagram of a bright point position detection unit according to the second embodiment of the present invention;

Fig. 10 is a circuit diagram of a memory controller according to the second embodiment of the present invention;

Fig. 11 is a view showing a setting example of regions for an ellipse; and

Fig. 12 is a flow chart of a conventional program.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] An embodiment of an ophthalmologic apparatus for obtaining the position of a bright point by image processing according to the present invention will be described below with reference to the accompanying drawings.

[0022] In this embodiment, the positions of bright points reflected by the cornea of an eye to be examined are calculated to measure the curvature of the cornea. Also, the present invention can be applied to an ophthalmologic apparatus for measuring the eye refracting power.

[0023] Fig. 1 shows an optical system of an ophthalmologic apparatus for measuring the curvature of a cornea. The optical system comprises a fixation index optical system 100 for fixing the visual axis of an eye 101 to be examined, an

illumination means 102 for radiating a light beam onto the eye 101 to be examined, and an image pickup optical system 103 for forming a cornea reflected image formed by the illumination means 102 on an image pickup unit 111.

[0024] The fixation index optical system 100 comprises a total reflection mirror 104, a condenser lens 105, a fixation index 106, and a fixation index illumination light source 107. The fixation index 106 and the fixation index illumination light source 107 are arranged in a fixation index block 108, which is movable in the optical axis direction.

[0025] The fixation index illumination light source 107 outputs visible light.

[0026] When the fixation index block 108 is moved in the optical axis direction, the diopter of the eye 101 to be examined can be adjusted.

[0027] The illumination means 102 comprises four measurement light sources 102a and 102b (the remaining two light sources are not shown) for radiating a light beam onto the eye 101 to be examined.

[0028] Each measurement light source preferably outputs infrared rays.

[0029] The image pickup optical system 103 comprises a projection lens 109, an aperture 110, and the image pickup unit 111.

[0030] A light splitting member 112 for allowing infrared rays to pass therethrough, and reflecting visible light is arranged along the optical axis between the fixation index optical system 100 and the image pickup optical system 103.

[0031] In the ophthalmologic apparatus with the above arrangement, light emitted from the fixation index illumination light source 107 is transmitted through the fixation index, and is then radiated onto the eye 101 to be examined via the condenser lens 105, the total reflection mirror 104, and the light splitting member 112.

[0032] Then, the fixation index block 108 is moved in the optical axis direction to fix the visual axis of the eye 101 to be examined.

[0033] In this state, when infrared rays emitted from the four measurement light sources 102a and 102b are radiated onto the eye 101 to be examined, and an image on the cornea of the eye 101 to be examined is picked up by the image pickup unit 111, a light source image (to be referred to as bright points hereinafter), as shown in Fig. 2, is formed.

[0034] The infrared rays forming the bright points are transmitted through the light splitting member 112, and the images of the bright points are formed on the image pickup unit 111 via the projection lens 109 and the aperture 110.

[0035] Note that light emitted from the fixation index illumination light source 107 and reflected by the cornea of the eye to be examined is reflected by the light splitting member 112.

[0036] Fig. 3 shows in more detail the four bright points formed on the image pickup unit 111 shown in Fig. 2, and is a view for explaining regions as a plurality of groups, each of which is expected to include one bright point formed by the light beam radiated on the eye to be examined and reflected by the cornea. As shown in Fig. 3, the infrared rays emitted from the measurement light sources 102a and 102b (Fig. 1) are radiated onto the eye 101 to be examined, so that the four bright points (bright points 1 to 4) are included one by one in four groups (to be referred to as regions hereinafter) obtained by dividing an image by two straight lines 30 ($y = -x + 511$) and 40 ($y = x$).

[0037] Fig. 4 is a block diagram of a portion associated with detection of the positions of bright points (bright point position detection unit) of the ophthalmologic apparatus according to the first embodiment of the present invention.

[0038] The bright point position detection unit comprises a video camera 111 as the image pickup unit, an amplifier 6, an A/D converter 7, a frame memory 8, an address controller 9, an MPU (microprocessor unit) 10, a latch 11, a magnitude comparator 12, an address generator 13, an area memory controller 14, and an area memory 15.

[0039] The video camera 111 has a plurality of pixels. The image of the eye 101 to be examined is picked up by the video camera 111. The picked-up image signals of the eye 101 to be examined are scanned in turn from the upper left pixel to the lower right pixel of the video camera 111, and are output to the amplifier 6.

[0040] A synchronization signal from the video camera 111 is output to the address generator 13. This synchronization signal is a signal representing the pixel of the video camera 111 from which the image signal is being read.

[0041] The image signals input to the amplifier 6 are amplified or attenuated, and are then input to the A/D converter 7. Image data which are sequentially converted into digital data by the A/D converter 7 are input to and stored (memorized) in the frame memory 8.

[0042] The address generator 13 generates a frame memory address corresponding to the synchronization signal of the pixel which outputs the image signal to the amplifier 6.

[0043] The frame memory address is output to the address controller 9 and the area memory 15.

[0044] When the image data memorized in the frame memory 8 are read by the MPU 10, the frame memory addresses of required image data are input from the address controller 9 to the frame memory 8.

[0045] Conversely, when the MPU 10 memorizes image data in the frame memory 8, the MPU 10 inputs the destination frame memory addresses to the frame memory 8.

[0046] The advantage of allowing the MPU 10 to make read/write accesses to the frame memory 8 in this manner will be described later.

[0047] On the other hand, the digital image data converted by the A/D converter 7 are held in the data latch 11, and are then input to the magnitude comparator 12. The image data are compared with a threshold set in advance in the MPU 10. As a result of comparison, if image data is larger than the threshold, the area memory controller 14 memorizes

the frame memory address at that time in the area memory 15.

[0048] Fig. 5 shows a circuit of the area memory controller 14 associated with write control to the area memory 15.

[0049] Referring to Fig. 5, the frame memory address generated by the address generator 13 is output to the area memory controller 14 via a frame memory address X coordinate signal line 31 and a frame memory address Y coordinate signal line 32.

[0050] The area memory controller 14 comprises an inverter 18, magnitude comparators 16 and 17, and AND gates 19a, 19b, 19c, and 19d.

[0051] The frame memory address X coordinate signal line 31 is connected to the inverter 18 and the magnitude comparator 17, and the frame memory address Y coordinate signal line 32 is connected to the magnitude comparators 16 and 17.

[0052] The comparator 16 is connected to the AND gates 19a, 19b, 19c, and 19d, and the comparator 17 is also connected to the AND gates 19a, 19b, 19c, and 19d.

[0053] The comparator 12 is also connected to the AND gates 19a, 19b, 19c, and 19d.

[0054] In the area memory controller 14 with the above arrangement, each of the X coordinate address output from the frame memory address X coordinate signal line 31, and the Y coordinate address output from the address Y coordinate signal line 32 is set to be 9-bit data so as to assume a value ranging from 0 to 51.

[0055] More specifically, if the X coordinate address is represented by an x value, and the x value is inverted by the inverter 18, an $\bar{x}$ value is (511 - x).

[0056] The comparator 16 receives the $\bar{x}$ value obtained by inverting the X coordinate address, and a y value as the Y coordinate address.

[0057] The comparator 17 receives the x value of the X coordinate address, and the y value of the Y coordinate address.

[0058] More specifically, when the y value is larger than the $\bar{x}$ value, the comparator 16 outputs an H-level signal (1); otherwise, i.e., when the y value is smaller than the $\bar{x}$ value, the comparator 16 outputs an L-level signal (0).

[0059] When the y value is larger than the x value, the comparator 17 outputs an H-level signal (1); otherwise, it outputs an L-level signal (0).

[0060] By combining the outputs from these comparators 16 and 17, a signal corresponding to the region (regions 1 to 4) of the frame memory address is obtained.

[0061] More specifically, a region above or below the straight lines 30 and 40 (Fig. 3) can be expressed by the outputs from the comparators 16 and 17, and can be classified into the regions 1 to 4.

[0062] When the signals from the comparators 16 and 17, and a signal output from the comparator 12 when image data exceeds the threshold are logically ANDed, writing signals 14a, 14b, 14c, and 14d for determining which one of partial memories 15a, 15b, 15c, and 15d of the area memory 15 memorizes the frame memory address are output to the area memory 15.

[0063] For example, the frame memory address in the region 1 is memorized in the partial memory 15a; the frame memory address in the region 2 is memorized in the partial memory 15b; the frame memory address in the region 3 is memorized in the partial memory 15c; and the frame memory address in the region 4 is memorized in the partial memory 15d.

[0064] In this case, in order to discriminate the boundary between each two adjacent regions, if "<" of the comparator 16 is replaced by "≤", or "≥" of the comparator 17 is replaced by "≥", the boundary can also be detected.

[0065] The frame memory address output from the address generator 13 is memorized in one of the partial memories 15a, 15b, 15c, and 15d in correspondence with the writing signals 14a, 14b, 14c, and 14d.

[0066] The partial memories 15a, 15b, 15c, and 15d are memories each for memorizing one frame memory address. A new frame memory address is overwritten on the previously memorized frame memory address.

[0067] After the image data of the eye 101 to be examined are stored in the frame memory 8, the frame memory addresses of the pixels finally scanned in the corresponding regions of the pixels exceeding the threshold in the corresponding regions are respectively memorized in the partial memories 15a to 15d.

[0068] The advantage of allowing the MPU 10 to make read/write accesses of the frame memory 8 is that the MPU 10 can confirm if accurate frame memory addresses are memorized in the area memory 15.

[0069] The MPU 10 reads out the frame memory addresses memorized in the partial memories 15a to 15d, and calculates the centroids of the bright points of the corresponding regions on the basis of the readout frame memory addresses.

[0070] The method of calculating the centroids will be described later.

[0071] Fig. 6 shows the positional relationship between the bright points memorized in the frame memory 8 and the regions, an enlarged plan view of one bright point, and the light intensity distribution along a line crossing the center of the bright point.

[0072] Note that the following description will be made with reference to a point ① in the bright point 4, which point ① is the first scanned point which exceeds the threshold.

[0073] Referring to Fig. 6, arrows illustrated on the enlarged view of the bright point 4 represent scanning lines. In the light intensity distribution along a line A-A on the enlarged view, the intensity of the luminance is highest at a center 43 of the bright point 4, the threshold is equal to the intensity of the luminance at a point 42, and the intensity of the luminance exceeds the noise level at a point 41. In the case of the bright point 4, the frame memory address of the point ① (of a pixel included therein) in the bright point 4, which point ① is the first scanned point which exceeds the threshold, is stored in the area memory 15d.

[0074] In this case, since a theoretical value of the recognition area of the bright point 4 is determined by the radiated light, the centroid of the bright point 4 can be calculated by determining the recognition area of the bright point 4 from, e.g., the radiation magnification of the measurement light sources 102a and 102b.

[0075] For example, as shown in Fig. 7, assume that the diameter of the bright point 4 is 2Rmax when the recognition area has a theoretical maximum value.

[0076] When an arbitrary one of pixels present in the bright point is selected, and its coordinates are represented by (x0, y0), as shown in Fig. 7, a square surrounded by coordinates (x0-2Rmax, y0-2Rmax), coordinates (x0+2Rmax, y0-2Rmax), coordinates (x0-2Rmax, y0+2Rmax), and coordinates (x0+2Rmax, y0+2Rmax) with reference to the coordinates (x0, y0) can always include the entire bright point.

[0077] This is because the coordinates (x0, y0) represent the point ①, as shown in Fig. 6, and this point corresponds to the coordinate value of the bright point, which value exceeds the threshold first.

[0078] When the above-mentioned square is generated based on the coordinates (x0, y0), the square can always include the entire bright point.

[0079] Therefore, a square including the bright point is calculated on the basis of the frame memory address which is stored in the area memory 15 and exceeds the threshold first, and the centroid of the bright point can be calculated for all pixels in the square in consideration of the noise level.

[0080] Note that the size of the square including the bright point shown in Fig. 7 can be decreased.

[0081] More specifically, 2Rmax may be assured from the coordinates (x0, y0) in the obliquely right downward direction (toward a coordinate point B in Fig. 7), and only Rmax may be assured in a direction of a coordinate point A.

[0082] In this case, although the square becomes small, the bright point is always included in the square. Since the square is small, the calculation time can be shortened.

[0083] When a square which always includes a bright point is calculated, as described above, the image data corresponding to the square are read from the frame memory 8, and the centroid of the bright point is calculated based on the read image data.

[0084] A method of calculating the centroid will be described below.

[0085] For the sake of simplicity, a case will be described below wherein the centroid of a rectangular region shown in Fig. 8 is to be calculated. The region shown in Fig. 8 includes 16 pixels, and addresses (X coordinate, Y coordinate) of these pixels are (1, 1), (1, 2), (1, 3), (1, 4), (2, 1), (2, 2),..., (1, 4), (2, 4), (3, 4), and (4, 4), and luminance data of these pixels are respectively 0, 1, 1, 0, 1, 2, 2, 1, 1, 2, 2, 1, 0, 1, 1, and 0 in turn.

[0086] In the region shown in Fig. 8, for example, the noise level is defined to be 1. The address of a pixel whose luminance is equal to or higher than the noise level is represented by (Xi, Yj) (for each of i and j is one of 1, 2, 3, and 4), and the luminance at the address (Xi, Yj) is represented by Pij. At this time, if the centroid of this rectangular region is represented by (X0, Y0), X0 and Y0 are calculated as follows. More specifically, the centroid is (2.5, 2.5).

$$X0 = \frac{\sum_{i} Xi \cdot Pij}{\sum_{i} Pij}$$

$$Y0 = \frac{\sum_{i} Yi \cdot Pij}{\sum_{i} Pij}$$

$$X0 = \frac{(2 \cdot 1 + 3 \cdot 1 + 1 \cdot 1 + 2 \cdot 2 + 3 \cdot 2 + 4 \cdot 1 + 1 \cdot 1 + 2 \cdot 2 + 3 \cdot 2 + 4 \cdot 1 + 2 \cdot 1 + 3 \cdot 1)}{(1+1+1+2+2+1+1+2+2+1+1+1)}$$
$$= \frac{40}{16}$$
$$= 2.5$$

$$Y0 = \frac{(1 \cdot 1 + 1 \cdot 1 + 2 \cdot 1 + 2 \cdot 2 + 2 \cdot 2 + 2 \cdot 1 + 3 \cdot 1 + 3 \cdot 2 + 3 \cdot 2 + 3 \cdot 1 + 4 \cdot 1 + 4 \cdot 1)}{(1+1+1+2+2+1+1+2+2+1+1+1)}$$
$$= \frac{40}{16}$$
$$= 2.5$$

[0087] Note that the memories 15a to 15d may store only the addresses at which the value of data exceeds the threshold finally in each region.

[0088] Fig. 9 is a block diagram of a portion associated with detection of the positions of bright points (bright point position detection unit) of the ophthalmologic apparatus according to the second embodiment of the present invention.

[0089] In the first embodiment, the shapes of the regions 1 to 4 are fixed to those shown in Fig. 3. However, in the second embodiment, the regions 1 to 4 can be set to have complicated shapes. A difference between the second and first embodiment is that a frame memory 58 comprises an image data memory section 58a and a region memory section 58b, and an area memory controller 54 writes addresses in the memories 15a to 15d corresponding to regions designated by the region memory section 58b.

[0090] Fig. 10 shows a circuit of the area memory controller 54 associated with write control to the memory 15, and the memory formats of the image data memory section 58a and the region memory section 58b of the frame memory 58.

[0091] The frame memory 58 stores pixel data (luminance information) of pixels and region information (information indicating the regions 1 to 4). As shown in Fig. 10, the frame memory 58 stores one address as 16-bit data. The lower 8 bits (bits 0 to 7) of the 16-bit data store image data as the image data memory section 58a, and the upper 8 bits (bits 8 to 15) store region information as the region memory section 58b.

[0092] Of the region information of the upper 8 bits, bits 12 to 15 are undefined bits to provide versatility. Bits 8 to 11 respectively correspond to the regions. That is, if bit 8 = 1, it indicates a pixel of the region 1; if bit 9 = 1, a pixel of the region 2; if bit 10 = 1, a pixel of the region 3; and if bit 11 = 1, a pixel of the region 4. Information indicating the region where the corresponding pixel is present is written in advance in the region memory section 58b, and the information indicating the region is read by the controller 54 while storing image data.

[0093] Which partial memory of the area memory 15 memorizes the frame memory address output from the address generator 13 is determined based on the bit indicating the area, which bit is read out from the controller 54.

[0094] With this arrangement, a circuit for determining the region to which a pixel belongs can be omitted unlike in the first embodiment. Also, a region having a complicated shape can be set. Furthermore, the shape of the region can be easily changed.

[0095] In this embodiment, the centroids of the four bright points are calculated. However, the present invention can be applied to detection of a larger number of bright points, as a matter of course. Also, the present invention can be applied to a case wherein a ring image is projected onto the cornea or the fundus of the eye in place of bright points, and an equation of ellipse is obtained from the projected image. In order to obtain the equation of ellipse, the coordinates of five points on an ellipse need only be obtained. Therefore, as shown in Fig. 11, five regions are set for an ellipse 23, and the address at which the luminance exceeds the threshold can be detected for each region.

[0096] A further detailed description about Fig. 11 will be given below. Referring to Fig. 11, a light source having a pattern (circular pattern) formed with a circular light-shielding portion is used as the illumination means 102, and the circular pattern is projected onto the eye to be examined. A circular pattern image reflected by the eye to be examined is an ellipse 23, as shown in Fig. 11.

[0097] The curvature of the cornea is then calculated based on the circular pattern and the ellipse 23.

[0098] When the curvature of the cornea is calculated, five regions each having a predetermined width are set on the ellipse 23 at equal angular intervals.

[0099] As the width of the region is smaller, the number of points crossing the ellipse 23 becomes smaller, and the calculation processing speed can be increased.

[0100] Therefore, in the following description, each region is defined by a line segment.

[0101] More specifically, the addresses of pixels of the ellipse 23, which pixels cross the regions, are obtained, and when the equation of ellipse is obtained based on the addresses of these pixels, the curvature of the eye to be examined can be calculated.

[0102] Note that the regions need not always be set at equal angular intervals.

[0103] The frame memory 8 is not always needed in the present invention. Even when the frame memory 8 is omitted, image data exceeding the threshold, and the addresses of the image data can be detected.

[0104] However, when the frame memory 8 is arranged, it can be confirmed if the image data exceeding the threshold, and the addresses of the image data coincide with each other, and the measured values of the eye to be examined can be calculated while displaying an image on a TV screen.

[0105] In place of the frame memory 8, an observation optical system may be added to the ophthalmologic apparatus.

Claims

1. An ophthalmologic apparatus comprising:

   radiation means (102) for radiating light onto an eye (101) to be examined;
   image pickup means (111) having a number of pixels for producing image data of the eye (101) to be examined, which is irradiated with light emitted from said radiation means (102);
   comparison means (12) for comparing the image data produced by pixels of said image pickup means with a threshold determined in advance for the image data;
   memory means (15) for storing information indicating the position of a pixel producing image data which is determined to be larger than said threshold by said comparison means (12); and
   calculation means (10) for calculating a value corresponding to a characteristic of the eye (101) to be examined on the basis of said position information stored in said memory means (15),
   characterised in that said comparison means (12) is arranged to perform said comparison of said image data in real time as the image data is outputted from the image pickup means (111).

2. An apparatus according to claim 1, wherein:

   the apparatus further comprises a frame memory (8,58) for storing image data obtained from each of said pixels of said image pickup means (111);
   said comparison means (12) is arranged to perform said comparison at the same time as said frame memory (8,58) stores said image data; and
   said memory means (15) is arranged to store an address, in said frame memory (8,58), of the pixel in which the image data is determined by said comparison means (12) to be larger than said threshold.

3. An apparatus according to claim 2, wherein said image pickup means (111) is arranged to pick up bright points which are formed when the light emitted from said radiation means (102) is reflected by at least one of a fundus or a cornea of the eye to be examined.

4. An apparatus according to claim 2 or 3 wherein said calculation means (10) is arranged to calculate said value corresponding to a characteristic of the eye to be examined on the basis of said address stored in said memory means (15) and said image data stored in said frame memory.

5. An apparatus according to any preceding claim, wherein said calculation means (10) is arranged to calculate the curvature of the cornea of the eye to be examined or the eye refracting power of the eye to be examined.

6. An apparatus according to any preceding claim, wherein:

   said image pickup means (111) comprises a video camera; and
   said apparatus further comprises a converter (7) for converting analogue data representing said image information obtained from said video camera into digital data.

7. An apparatus according to claim 1, wherein:

   said radiation means (102) is arranged to radiate a plurality of rays onto said eye to be examined;
   said image pickup means (111) is arranged to pick up an image such that the image data includes data for bright points of said eye being examined, which are formed when the rays emitted from said radiation means (102) are reflected by the eye being examined;
   said apparatus further comprises a frame memory (8,58) for storing image data obtained from each pixel of said image pickup means (111) and grouping means (14,54) for grouping said image data obtained from said

image pickup means (111) into a plurality of groups each of which includes one bright point;

said comparison means (12) is arranged to compare, when said frame memory (8,58) stores said image data, image data obtained from said image pickup means (111) with a threshold determined for each of said groups;
said memory means (15) is arranged to store an address, in said frame memory (8,58), of the pixel in which the image data is determined by said comparison means (12) to be larger than said threshold, for each of said groups grouped by said grouping means (14,54) and;
said calculation means (10) is arranged to calculate said value corresponding to a characteristic of the eye being examined on the basis of the address stored in said memory means (15).

8. An apparatus according to claim 7 wherein the comparison means is arranged such that the image data which is larger than said threshold are obtained from the pixels which pick up said bright points, and said memory means (15) is arranged to store, for each of said groups, the address of at least one pixel which picks up said one bright point.

9. An apparatus according to claim 7 or 8, wherein said grouping means (14,54) has group information determination means (16,17,18) for determining group information for said image data, when said frame memory (8,58) stores said image data, and wherein said memory means (15) is arranged to be controlled in such a way as to store said address for each of said groups in accordance with said group information.

10. An apparatus according to claim 7, 8 or 9, wherein said calculation means (10) is arranged to calculate rectangles each including a said bright point on the basis of said address stored in said memory means (15) and an arbitrary condition of said radiation means (102), to read out the calculated rectangles from said frame memory (8,58) and to calculate a centroid of the bright points, thereby to calculate said value corresponding to a characteristic of the eye being examined.

11. An apparatus according to claim 2, wherein:

said radiation means (102) is arranged to radiate a plurality of rays onto said eye being examined;
said image pickup means (111) is arranged to pick up an image such that the image data includes data for bright points of said eye being examined, which are formed when the rays emitted from said radiation means (102) are reflected by the eye being examined;
the apparatus further comprises:
bright point prediction/memory means for predicting and memorizing sizes of the bright points generated by said rays;
pixel selection means for selecting pixels near the address stored in said memory means (15), from said frame memory (8,58) on the basis of the address stored in said memory means (15) and said sizes of the bright points stored in said bright point prediction/memory means; and
means for extracting pixels producing image data exceeding said threshold from the pixels selected by said pixel selection means; and
said calculation means is arranged to calculate a position of a centroid of the bright points on the basis of the pixels extracted by said extraction means so as to obtain said value corresponding to a characteristic of the eye being examined.

Patentansprüche

1. Augenheilkundegerät, das aufweist: eine Strahlungseinrichtung (102) zum Strahlen von Licht auf ein Auge (101), das untersucht werden soll;

eine Bildaufnahmeeinrichtung (111), die eine Anzahl von Pixeln zum Produzieren von Bild-Daten des Auges (101), das untersucht werden soll, besitzt, das mit Licht bestrahlt wird, das von der Strahlungseinrichtung (102) emittiert ist;
eine Vergleichseinrichtung (12) zum Vergleichen der Bild-Daten, die durch Pixel der Bildaufnahmeeinrichtung produziert sind, mit einem Schwellwert, der im voraus für die Bild-Daten bestimmt ist;
eine Speichereinrichtung (15) zum Speichern von Informationen, die die Position eines Pixels anzeigen, was Bild-Daten produziert, die dahingehend bestimmt sind, größer als der Schwellwert zu sein, durch die Vergleichseinrichtung (12); und
eine Berechnungseinrichtung (10) zum Berechnen eines Werts entsprechend einer Charakteristik des Auges (101), das untersucht werden soll, auf der Basis der Positions-Informationen, die in der Speichereinrichtung

(15) gespeichert sind,
dadurch gekennzeichnet, daß die Vergleichseinrichtung (12) so aufgebaut ist, um den Vergleich der Bild-Daten in einer Realzeit durchzuführen, wenn die Bild-Daten von der Bildaufnahmeeinrichtung (111) ausgegeben werden.

2. Gerät nach Anspruch 1, wobei:

das Gerät weiterhin einen Einzelbildspeicher (8, 58) zum Speichern von Bild-Daten, die von jedem der Pixel der Bildaufnahmeeinrichtung (111) erhalten sind, aufweist;
wobei die Vergleichseinrichtung (12) so aufgebaut ist, um den Vergleich zu derselben Zeit durchzuführen, zu der der Einzelbildspeicher (8, 58) die Bild-Daten speichert; und
wobei die Speichereinrichtung (15) so aufgebaut ist, um eine Adresse, in dem Einzelbildspeicher (8, 58), des Pixels, bei dem die Bild-Daten durch die Vergleichseinrichtung (12) dahingehend bestimmt sind, größer als der Schwellwert zu sein, zu speichern.

3. Gerät nach Anspruch 2, wobei die Bildaufnahmeeinrichtung (111) so aufgebaut ist, um helle Punkte aufzunehmen, die dann gebildet werden, wenn das Licht, das von der Strahlungseinrichtung (102) emittiert ist, durch mindestens den Augenhintergrund oder eine Cornea des Auges, das untersucht werden soll, reflektiert ist.

4. Gerät nach Anspruch 2 oder 3, wobei die Berechnungseinrichtung (10) so aufgebaut ist, um den Wert entsprechend zu einer Charakteristik des Auges, das untersucht werden soll, auf der Basis der Adresse, die in der Speichereinrichtung (15) gespeichert ist, und der Bild-Daten, die in dem Einzelbildspeicher gespeichert sind, zu berechnen.

5. Gerät nach einem vorhergehenden Anspruch, wobei die Berechnungseinrichtung (10) so aufgebaut ist, um die Krümmung der Cornea des Auges, das untersucht werden soll, oder die Augenrefraktionsleistung des Auges, das untersucht werden soll, zu berechnen.

6. Gerät nach einem vorhergehenden Anspruch, wobei:

die Bildaufnahmeeinrichtung (111) eine Videokamera aufweist; und
das Gerät weiterhin einen Wandler (7) zum Wandeln analoger Daten, die die Bild-Informationen darstellen, die von der Videokamera erhalten sind, in digitale Daten aufweist.

7. Gerät nach Anspruch 1, wobei:

die Strahlungseinrichtung (102) so aufgebaut ist, um eine Vielzahl von Strahlen auf das Auge, das untersucht werden soll, zu strahlen;
die Bildaufnahmeeinrichtung (111) so aufgebaut ist, um ein Bild aufzunehmen derart, daß die Bild-Daten Daten, für helle Punkte des Auges, das untersucht werden soll, umfassen, die dann gebildet werden, wenn die Strahlen, die von der Strahlungseinrichtung (102) emittiert sind, durch das Auge, das untersucht wird, reflektiert werden;
wobei das Gerät weiterhin einen Einzelbildspeicher (8, 58) zum Speichern von Bild-Daten, die von jedem Pixel der Bildaufnahmeeinrichtung (111) erhalten sind, und eine Gruppiereinrichtung (14, 54) zum Gruppieren der Bild-Daten, die von der Bildaufnahmeeinrichtung (111) erhalten sind, in eine Vielzahl von Gruppen, wobei jede davon einen hellen Punkt umfaßt, aufweist;
wobei die Vergleichseinrichtung (12) so aufgebaut ist, um, wenn der Einzelbildspeicher (8, 58) die Bild-Daten speichert, die Bild-Daten, die von der Bildaufnahmeeinrichtung (111) erhalten sind, mit einem Schwellwert, der für jede der Gruppen bestimmt ist, zu vergleichen;
wobei die Speichereinrichtung (15) so aufgebaut ist, um eine Adresse, in dem Einzelbildspeicher (8, 58), des Pixels, bei dem die Bild-Daten durch die Vergleichseinrichtung (12) dahingehend bestimmt sind, größer als der Schwellwert zu sein, für jede der Gruppen, gruppiert durch die Gruppiereinrichtung (14, 54), zu speichern, und;
die Berechnungseinrichtung (10) so aufgebaut ist, um den Wert entsprechend zu einer Charakteristik des Auges, das untersucht werden soll, auf der Basis der Adresse, die in der Speichereinrichtung (15) gespeichert ist, zu berechnen.

8. Gerät nach Anspruch 7, wobei die Vergleichseinrichtung so aufgebaut ist, daß die Bild-Daten, die größer als der

Schwellwert sind, von den Pixeln erhalten werden, die die hellen Punkte aufnehmen, und wobei die Speichereinrichtung (15) so aufgebaut ist, um, für jede der Gruppen, die Adresse mindestens eines Pixels zu speichern, das den einen hellen Punkt aufnimmt.

9. Gerät nach Anspruch 7 oder 8, wobei die Gruppiereinrichtung (14, 54) eine Gruppen-Informations-Bestimmungseinrichtung (16, 17, 18) zum Bestimmen von Gruppen-Informationen für die Bild-Daten besitzt, wenn der Einzelbildspeicher (8, 58) die Bild-Daten speichert, und wobei die Speichereinrichtung (15) so aufgebaut ist, um in einer solchen Art und Weise gesteuert zu werden, um die Adresse für jede der Gruppen gemäß der Gruppen-Informationen zu speichern.

10. Gerät nach Anspruch 7, 8 oder 9, wobei die Berechnungseinrichtung (10) so aufgebaut ist, um Rechtecke zu berechnen, von denen jedes einen hellen Punkt besitzt, auf der Basis der Adresse, die in der Speichereinrichtung (15) gespeichert ist, und einem wahlweisen Zustand der Strahlungseinrichtung (102), um die berechneten Rechtecke aus dem Einzelbildspeicher (8, 58) auszulesen und um einen Schwerpunkt der hellen Punkte zu berechnen, um dadurch den Wert entsprechend zu einer Charakteristik des Auges, das untersucht werden soll, zu berechnen.

11. Gerät nach Anspruch 2, wobei:

die Strahlungseinrichtung (102) so aufgebaut ist, um eine Vielzahl von Strahlen auf das Auge, das untersucht werden soll, zu strahlen;
die Bildaufnahmeeinrichtung (111) so aufgebaut ist, um ein Bild aufzunehmen, so daß die Bild-Daten Daten für helle Punkte des Auges, das untersucht werden soll, umfassen, die dann gebildet werden, wenn die Strahlen, die von der Strahlungseinrichtung (102) emittiert sind, durch das Auge, das untersucht werden soll, reflektiert werden;
wobei das Gerät weiterhin aufweist:
eine Vorhersage/Speichereinrichtung für helle Punkte zum Vorhersagen und Speichern von Größen der hellen Punkte, die durch die Strahlen erzeugt sind;
eine Pixel-Auswahleinrichtung zum Auswählen von Pixeln nahe der Adresse, die in der Speichereinrichtung (15) gespeichert ist, von dem Einzelbildspeicher (8, 58) auf der Basis der Adresse, die in der Speichereinrichtung (15) gespeichert ist, und der Größen der hellen Punkte, die in der Vorhersage/Speichereinrichtung für die hellen Punkte gespeichert sind; und
eine Einrichtung zum Extrahieren von Pixeln, die Bild-Daten produzieren, die den Schwellwert übersteigen, von den Pixeln, die durch die Pixel-Auswahleinrichtung ausgewählt sind; und
wobei die Berechnungseinrichtung so aufgebaut ist, um eine Position eines Schwerpunkts der hellen Punkte auf der Basis der Pixel, die durch die Extraktionseinrichtung extrahiert sind, zu berechnen, um so den Wert entsprechend zu einer Charakteristik des Auges, das untersucht werden soll, zu erhalten.

Revendications

1. Appareil ophtalmologique comprenant :

un moyen de rayonnement (102) pour irradier de la lumière sur un oeil (101) à examiner,
un moyen de prise ou d'enregistrement d'image (111) ayant un certain nombre de pixels pour produire des données d'image de l'oeil (101) à examiner, qui est irradié par de la lumière émise par ledit moyen de rayonnement (102),
un moyen de comparaison (12) pour comparer les données d'image produites par les pixels dudit moyen d'enregistrement d'image à un seuil déterminé à l'avance pour les données d'images,
un moyen de mémorisation (15) pour stocker les informations indiquant la position d'un pixel produisant des données d'image déterminées comme étant plus grandes que ledit seuil par ledit moyen de comparaison (12), et
un moyen de calcul (10) pour calculer une valeur correspondant à une caractéristique de l'oeil (101) à examiner sur la base desdites informations de position stockées dans ledit moyen de mémorisation (15), caractérisé en ce que ledit moyen de comparaison (12) est agencé pour effectuer ladite comparaison desdites données d'image en temps réel lorsque les données d'image sont délivrées par le moyen d'enregistrement d'image (111).

2. Appareil selon la revendication 1, dans lequel :

l'appareil comprend par ailleurs une mémoire d'image (8, 58) pour stocker des données d'image obtenues de chacun desdits pixels dudit moyen d'enregistrement d'image (111),

ledit moyen de comparaison (12) est agencé pour effectuer ladite comparaison en même temps que ladite mémoire d'image (8, 58) stocke lesdites données d'image, et

ledit moyen de mémorisation (15) est agencé pour stocker, dans ladite mémoire d'image (8, 58), une adresse du pixel dans lequel les données d'image sont déterminées par ledit moyen de comparaison (12) comme étant plus grandes que ledit seuil.

3. Appareil selon la revendication 2, dans lequel ledit moyen d'enregistrement d'image (111) est agencé pour enregistrer des points brillants qui sont formés lorsque la lumière émise par ledit moyen de rayonnement (102) est réfléchie par au moins le fond ou la cornée de l'oeil à examiner.

4. Appareil selon la revendication 2 ou 3, dans lequel ledit moyen de calcul (10) est agencé pour calculer ladite valeur correspondant à une caractéristique de l'oeil à examiner sur la base de ladite adresse stockée dans ledit moyen de mémorisation (15) et desdites données d'image stockées dans ladite mémoire d'image.

5. Appareil selon l'une quelconque des revendications précédentes, dans lequel ledit moyen de calcul (10) est agencé pour calculer la courbure de la cornée de l'oeil à examiner ou le pouvoir réfringent de l'oeil à examiner.

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel :

ledit moyen d'enregistrement d'image (111) comprend une caméra vidéo, et

ledit appareil comprend par ailleurs un convertisseur (7) pour convertir les données analogiques représentant lesdites informations d'image obtenues à partir de la caméra vidéo en données numériques.

7. Appareil selon la revendication 1, dans lequel :

ledit moyen de rayonnement (102) est agencé pour irradier une pluralité de rayons sur ledit oeil à examiner,

ledit moyen d'enregistrement d'image (111) est agence pour enregistrer une image telle que les données d'image comprennent des données pour des points brillants dudit oeil à examiner, qui sont formés lorsque les rayons émis par ledit moyen de rayonnement (102) sont réfléchis par l'oeil en cours d'examen,

ledit appareil comprend par ailleurs une mémoire d'image (8, 58) pour stocker des données d'images obtenues à partir de chaque pixel dudit moyen d'enregistrement d'image (111) et un moyen de groupement (14, 54) pour regrouper lesdites données d'images obtenues à partir dudit moyen d'enregistrement d'image (111) en une pluralité de groupes, dont chacun comprend un point brillant,

ledit moyen de comparaison (12) est agencé pour comparer, lorsque ladite mémoire d'image (8, 58) stocke lesdites données d'image, des données d'image obtenues à partir dudit moyen d'enregistrement d'image (111) à un seuil déterminé pour chacun desdits groupes,

ledit moyen de mémorisation (15) est agencé pour stocker, dans ladite mémoire d'image (8, 58), une adresse du pixel dans lequel les données d'image sont déterminées par ledit moyen de comparaison (12) comme étant plus grandes que ledit seuil, pour chacun desdits groupes regroupés par ledit moyen de groupement (14, 54), et

ledit moyen de calcul (10) est agencé pour calculer ladite valeur correspondant à une caractéristique de l'oeil en cours d'examen sur la base de l'adresse stockée dans ledit moyen de mémorisation (15).

8. Appareil selon la revendication 7, dans lequel le moyen de comparaison est agencé de telle sorte que les données d'image qui sont plus grandes que ledit seuil soient obtenues à partir des pixels qui enregistrent lesdits points brillants, et ledit moyen de mémorisation (15) est agencé pour stocker, pour chacun desdits groupes, l'adresse d'au moins un pixel qui enregistre ledit au moins un point brillant.

9. Appareil selon la revendication 7 ou 8, dans lequel ledit moyen de groupement (14, 54) a un moyen (16, 17, 18) de détermination d'informations de groupes pour déterminer les informations de groupes pour lesdites données d'image, lorsque ladite mémoire d'image (8, 58) stocke lesdites données d'images, et dans lequel ledit moyen de mémorisation (15) est agencé pour être commandé de manière à stocker ladite adresse pour chacun desdits groupes conformément auxdites informations de groupes.

10. Appareil selon la revendication 7, 8 ou 9, dans lequel ledit moyen de calcul (10) est agencé pour calculer des rectangles, chacun comprenant un dit point brillant de ladite adresse stockée dans ledit moyen de mémorisation (15)

et une condition arbitraire dudit moyen de rayonnement (102), pour lire les rectangles calculés dans ladite mémoire d'image (8, 58) et calculer une zone centroïde des points brillants en sorte de calculer ladite valeur correspondant à une caractéristique de l'oeil en cours d'examen.

11. Appareil selon la revendication 2, dans lequel :

ledit moyen de rayonnement (102) est agencé pour irradier une pluralité de rayons sur ledit oeil en cours d'examen,
ledit moyen d'enregistrement d'images (111) est agencé pour enregistrer une image telle que les données d'image comprennent des données pour les points brillants dudit oeil en cours d'examen, qui sont formées lorsque les rayons émis par ledit moyen de rayonnement (102) sont réfléchis par l'oeil en cours d'examen,
l'appareil comprenant par ailleurs :
un moyen de prédiction/mémorisation de points brillants pour prédire et mémoriser les tailles des points brillants générés par lesdits rayons,
un moyen de sélection de pixels pour sélectionner les pixels proches de l'adresse stockée dans ledit moyen de mémorisation (15), dans ladite mémoire d'image (8, 58), sur la base de l'adresse stockée dans ledit moyen de mémorisation (15) et desdites tailles des points brillants stockés dans ledit moyen de prédiction/mémorisation de points brillants,
un moyen pour extraire des pixels produisant des données d'image dépassant ledit seuil à partir des pixels sélectionnés par ledit moyen de sélection de pixels, et
ledit moyen de calcul est agencé pour calculer une position d'un emplacement centroïde des points brillants sur la base des pixels extraits par ledit moyen d'extraction de manière à obtenir ladite valeur correspondant à une caractéristique de l'oeil en cours d'examen.

FIG. 1

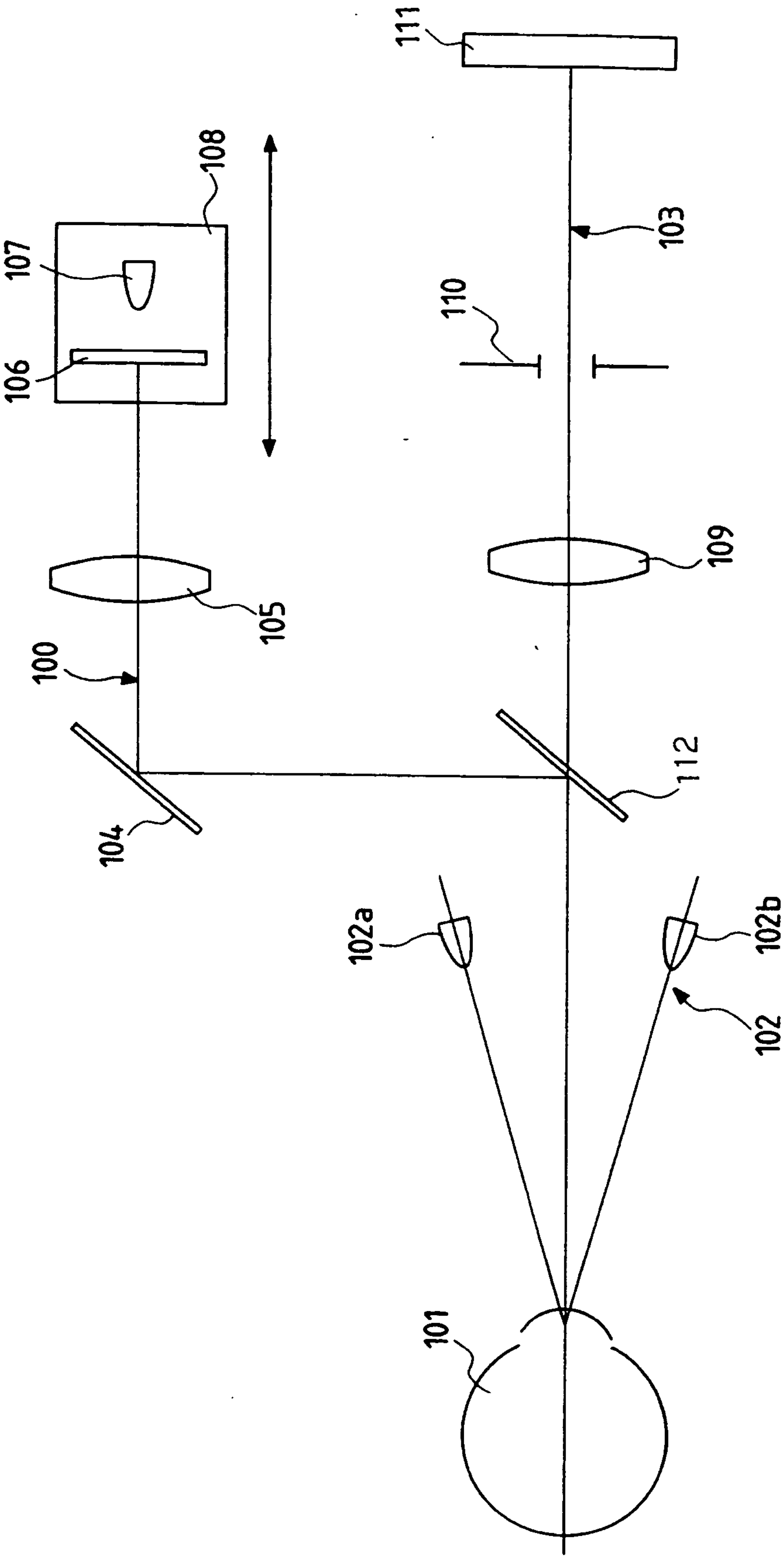


FIG. 2

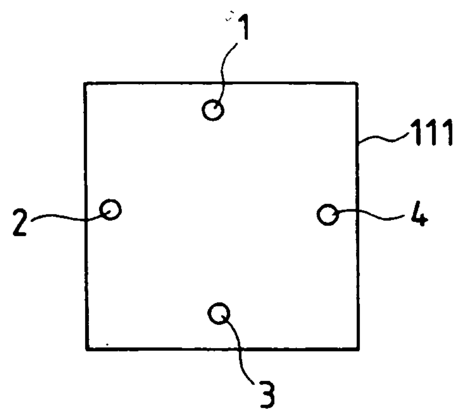
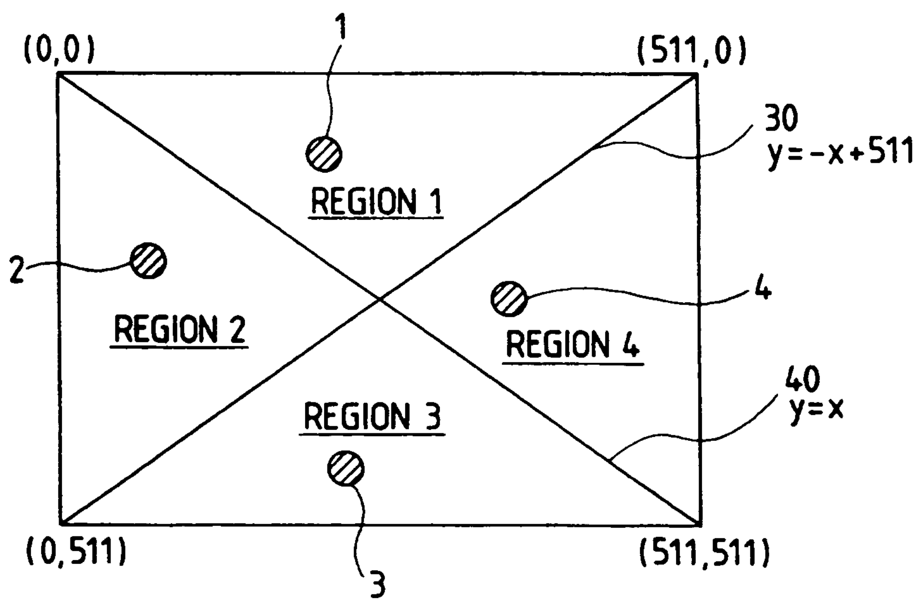

1
111
2
4
3

FIG. 3


(0,0)
1
(511,0)
30
y=-x+511
REGION 1
2
4
REGION 2
REGION 4
40
y=x
REGION 3
(0,511)
(511,511)
3

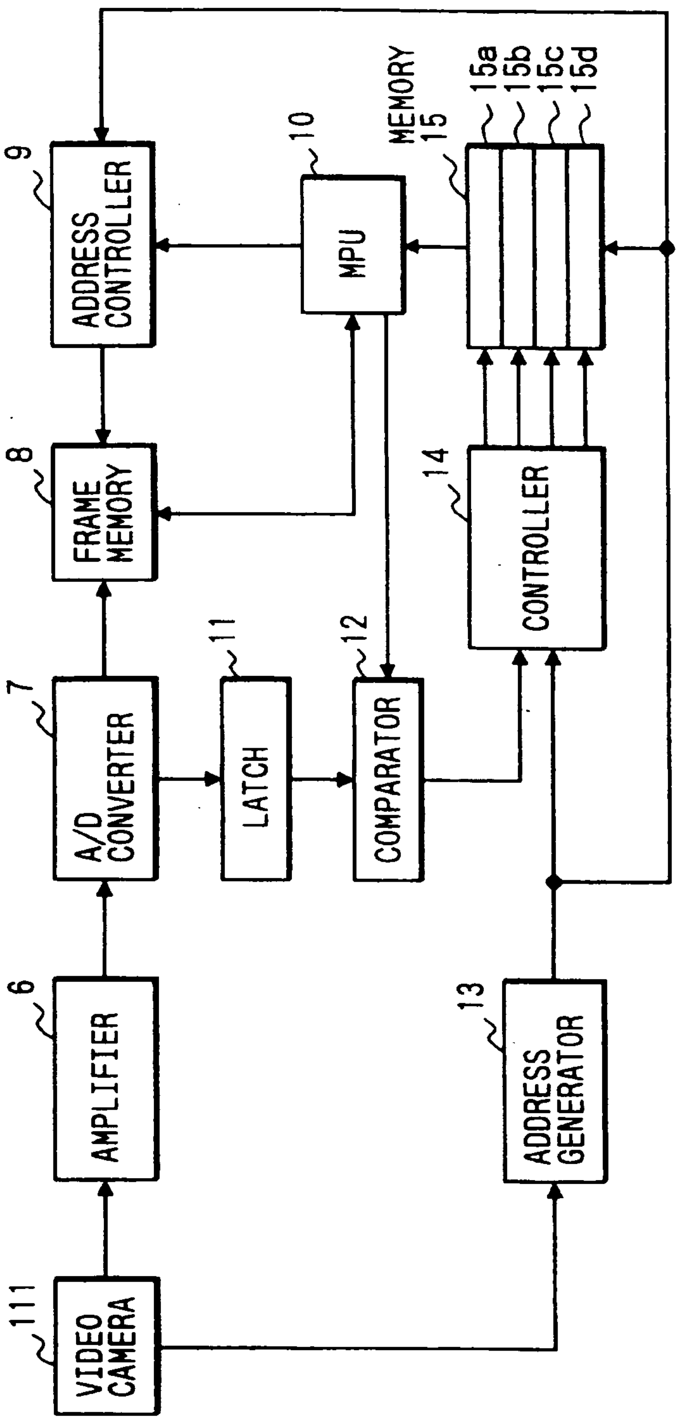

VIDEO CAMERA
111
AMPLIFIER
6
A/D CONVERTER
7
FRAME MEMORY
8
ADDRESS CONTROLLER
9
MPU
10
LATCH
11
COMPARATOR
12
ADDRESS GENERATOR
13
CONTROLLER
14
MEMORY
15
15a
15b
15c
15d

FIG. 4

FIG. 5

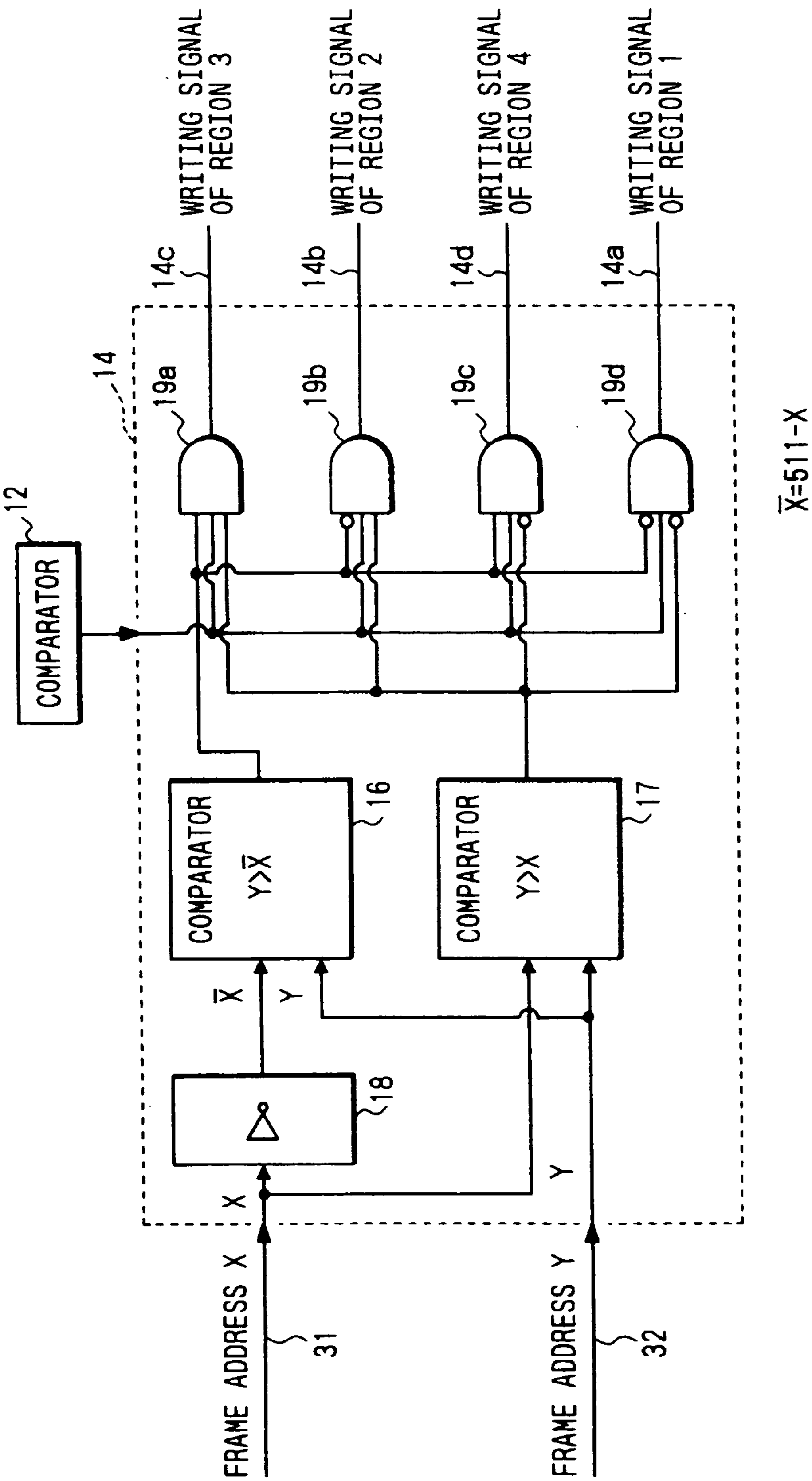
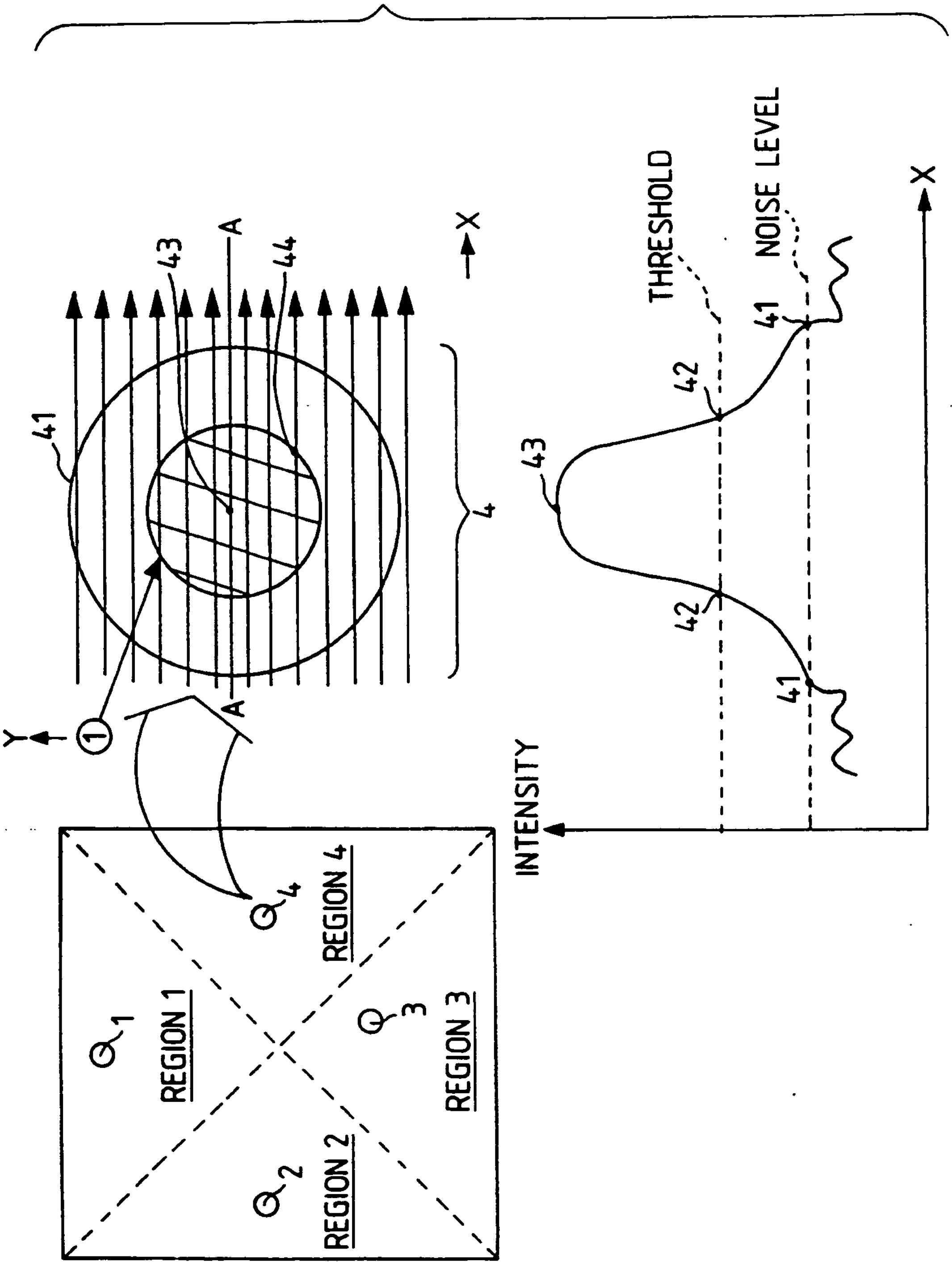

COMPARATOR
12
14
19a
19b
19c
19d
14c
14b
14d
14a
WRITING SIGNAL OF REGION 3
WRITING SIGNAL OF REGION 2
WRITING SIGNAL OF REGION 4
WRITING SIGNAL OF REGION 1
COMPARATOR Y>X̄
16
COMPARATOR Y>X
17
18
X̄
Y
X
Y
FRAME ADDRESS X
31
FRAME ADDRESS Y
32
X̄=511-X

FIG. 6



41
43
44
A
A
X
Y
1
4
42
42
41
41
43
THRESHOLD
NOISE LEVEL
X
INTENSITY
REGION 1
REGION 2
REGION 3
REGION 4
Q1
Q2
Q3
Q4

FIG. 7

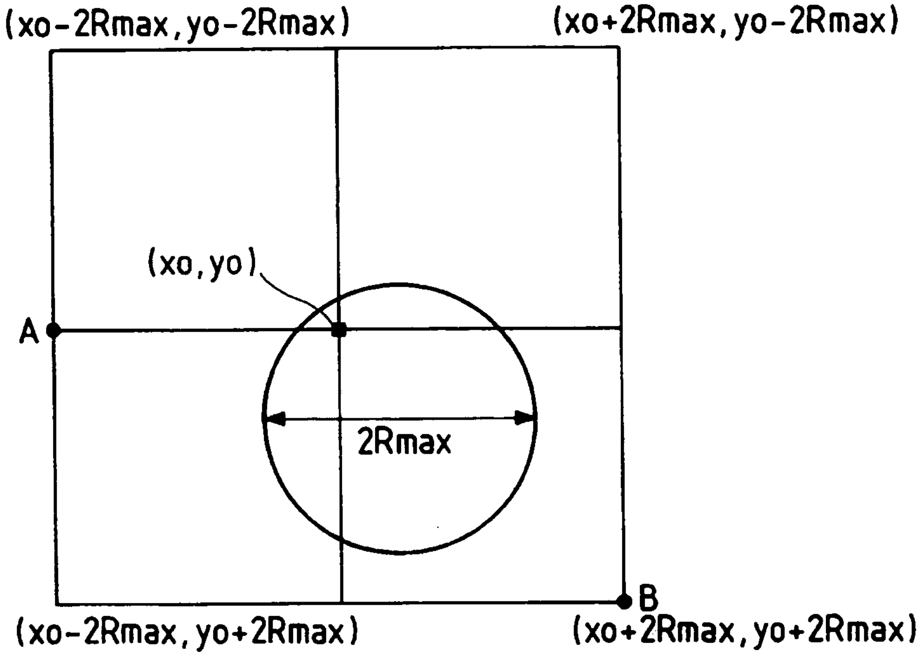


FIG. 8

Y \ X	1	2	3	4
1	0	1	1	0
2	1	2	2	1
3	1	2	2	1
4	0	1	1	0

FIG. 9

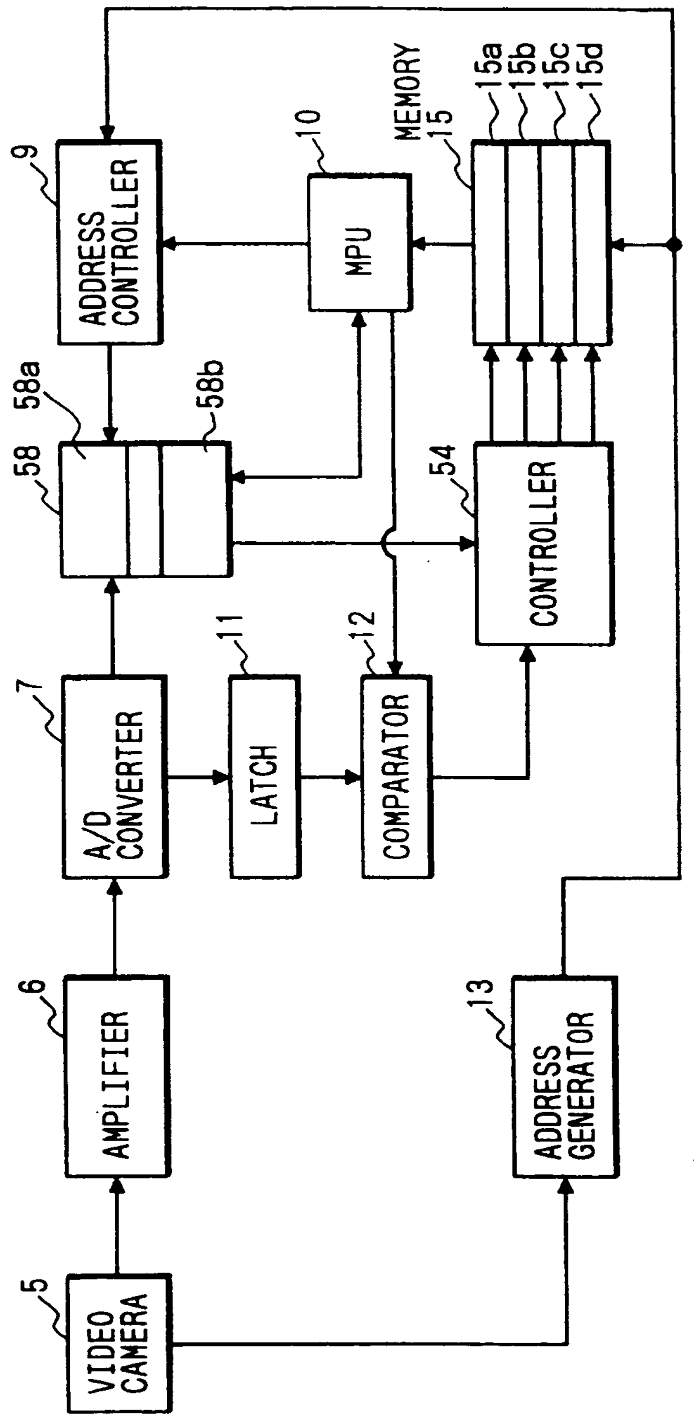

VIDEO CAMERA
5
AMPLIFIER
6
A/D CONVERTER
7
LATCH
11
COMPARATOR
12
58
58a
58b
ADDRESS CONTROLLER
9
MPU
10
MEMORY
15
15a
15b
15c
15d
CONTROLLER
54
ADDRESS GENERATOR
13

FIG. 10

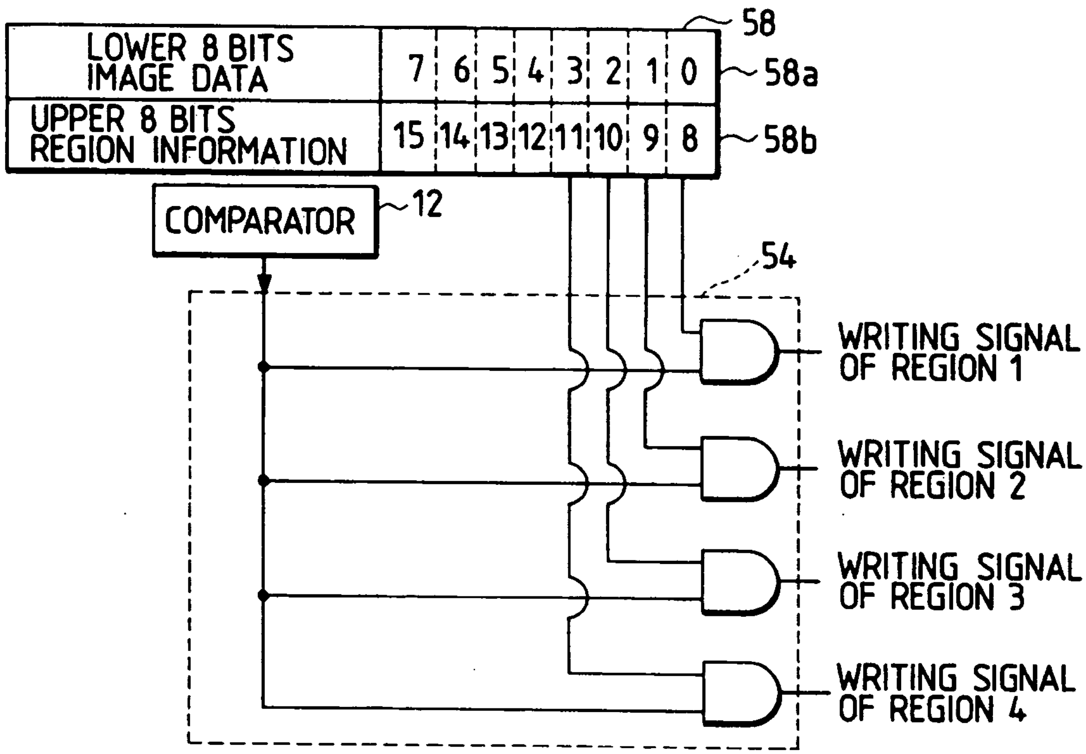

LOWER 8 BITS IMAGE DATA
7 6 5 4 3 2 1 0
UPPER 8 BITS REGION INFORMATION
15 14 13 12 11 10 9 8
58
58a
58b
COMPARATOR
12
54
WRITING SIGNAL OF REGION 1
WRITING SIGNAL OF REGION 2
WRITING SIGNAL OF REGION 3
WRITING SIGNAL OF REGION 4

FIG. 11

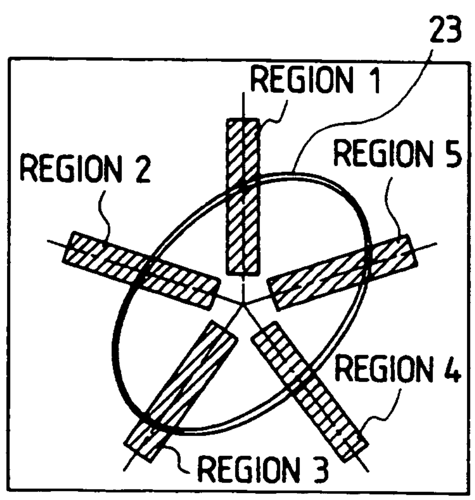

23
REGION 1
REGION 2
REGION 5
REGION 4
REGION 3

FIG. 12
PRIOR ART